Jason Cornelius

The Pennsylvania State University

Universities Space Research Association

Undergraduate Intern

Mentor: Natasha Barbely
Code: ARC-AV
Branch Title: Aeromechanics

Acoustic Analysis of Multicopter UAS 7x10 Wind Tunnel Test

Small Unmanned Aircraft Systems (UAS) are finding increased use in today's civil market while the Federal Aviation Administration (FAA) has been working diligently toward commercializing the use of these vehicles. Noise generated by UAS must be mitigated to minimize impact on the community and environment. To aid in understanding the acoustic signature from these aircraft, acoustic measurements were taken of several UAS vehicles during the Unmanned Aircraft System Traffic Management Build 1 flight test at Crows Landing. Additionally, in the winter of 2015 a multicopter UAS vehicle performance test was conducted in the NASA Ames 7-by 10-ft wind tunnel. Three microphones were installed in the test section and were used to measure acoustics. The acoustic data is organized, processed and analyzed for 5 different UAS vehicles. The two different acoustic environments, wind tunnel and outdoor flight test, are compared to understand the quality of the acoustic environment in the 7-by 10-ft wind tunnel.

Kalki Sharma

Pennsylvania State University

Volunteer Internship Program (VIP)

Graduate Intern

Mentor: William Warmbrodt
Code: AV
Title: Aeromechanics Branch Chief

Incorporation of Noise Predictions into NDARC

Performing noise prediction for rotorcraft has generally been too computationally expensive to be incorporated into the earlier stages of the design process of rotorcraft. In order to decrease the time required, a lower fidelity noise prediction system has been developed. The system uses three main tools: PSU-WOPWOP, NASA Design and Analysis of Rotorcraft (NDARC), and WOPIt. PSU-WOPWOP is a noise prediction software written by Kenneth S. Brentner, NDARC is a design and analysis software written by Dr. Wayne Johnson, and WOPIT is the software interface which couples PSU-WOPWOP with NDARC.

The five noise sources which are predicted are thickness, loading, high speed impulsive (HSI), broadband, and interaction noise. While thickness and loading noise are predicted using the Ffowcs Williams and Hawkings equation, the other noise sources are predicted using semi-empirical and with simplified physics-based models. These models are employed to increase the prediction time and are tested for validity. For the most accurate results, CFD analysis can be employed, but for the early stages of the design process of rotorcraft these models should prove adequate.

The goal of this system is to give designers adequate tools to be able to perform fast and accurate noise prediction on the varying rotorcraft configurations in the conceptual and preliminary design stages and prior to flight testing.

Arlene Lopez

El Camino College

Universities Space Research Association (USRA)

Undergraduate Intern

Mentor: Dr. Ram Prasad Gandhiraman
Code: TSS
Entry Systems and Vehicle Development

Plasma Jet Printing and Characterization of Conductive Nanomaterials for Flexible Electronics

Advanced printing technology for flexible electronics and sensors could prove useful as an in-space manufacturing tool for future long-duration space missions. The ability to print conductive nano materials can reduce the dependency of mission crew on the transportation of materials from the ground. In-space fabrication technologies can help to mitigate overall mission cost and produce components critical for mission success and longevity. An aerosol assisted atmospheric pressure plasma-based printing process has been developed at NASA Ames Research Center. In the process, a plasma jet is used to carry and deposit aerosolized nanomaterials onto various substrates at room temperature. The fabrication process allows for the deposition of nanomaterials on curved or flat surfaces, as well as, non-conformal objects. The objective of this project is to deposit conductive nanomaterials for electronic applications. This will involve further developing and designing the plasma jet printing system and automating a stage for sample movement and patterning. Additionally, the plasma printed nanomaterials will be characterized using the Scanning Electron Microscopy (SEM), X-Ray Absorption Spectroscopy (XAS), and X-Ray Photoelectron Spectroscopy (XPS) characterization techniques.

Adam Ewert

New Mexico State University

Universities Space Research Association (USRA)

Undergraduate Intern

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Code: AV
Aeromechanics Branch

Second-generation Large Civilian Tiltrotor (LCTR2) Performance Analysis

The LCTR2 is designed to vertically take off and land while carrying 90 passengers for 1000 nm at 300 knots. In April 2012 and October 2013 a 6% scale model LCTR2 was tested in U.S. Army 7x10-Foot Wind Tunnel using the Army's High Efficiency Tiltrotor (HETR) wing. The model was mounted to the wind tunnel scale system with various strut configurations to measure all six forces and moments acting on the airframe in different modes. Tare measurements were taken for each configuration of the LCTR2. A function was fit to each set of tare data and then subtracted from the wind tunnel data to remove the aerodynamic and weight effects of the struts. This project confirms the accuracy of the tare functions in order to use the corrected data to optimize the parameters for a computational fluid dynamics (CFD) model of the LCTR2 with the HETR wing in RotCFD. The project also takes the optimized RotCFD parameters and uses them to model the LCTR2 with its own wing in place of the HETR wing. The RotCFD results will help validate the LCTR2 wing design and lead to modeling the effect of the LCTR2 rotors on the airframe in flight.

Alexander Grima

KTH Royal Institute of Technology

NASA International Internship Program

Masters

Dr. Colin Theodore
Dr. Ben Lawrence
Code AV
Aeromechanics

Aerodynamic Analysis of an Experimental Tiltwing Aircraft

The Elytron 2S (Elytron Aircraft Inc. 2016) is a prototype for an advanced VTOL concept aircraft consisting of a box wing and a small centrally mounted tiltwing with tilting rotors. The concept aircraft is proposed in two sizes, 4 and 10 seater, and is envisaged for use as an air taxi or perhaps for transportation of crews to/from oil and gas rigs. The aircraft design, attained after 10 years of research, should allow helicopter VTOL capabilities as well as fixed wing like speeds with greatly reduced cost in comparison to any existing solutions.

This project includes the modeling and analysis of the aerodynamic characteristics of the aircraft using computational analysis in AVL (Drela and Youngren 2016) and RotCFD (Sukra Helitek Inc. 2016). The aim of the research is to model the vehicle and enable predictions of aerodynamic performance for comparison with experimental results obtained through flight testing. In AVL the performance analysis is performed on the airframe without the fuselage or rotors due to the nature of the Vortex Lattice method. Whilst the analysis performed in RotCFD will be on the full aircraft, in both hover and forward flight, enabling the analysis of rotor flow interactions.

Haley Cummings

Northern Illinois University

Universities Space Research Association

Undergraduate
Intern

Mentor: Geoffrey Ament
Code: AV
Branch: Rotorcraft Aeromechanics

Mars Aeolian Wind Tunnel Test Stand Design

The exploration of Mars has long been a theme in science fiction entertainment. However, with successful NASA Mars rover missions such as Curiosity and Opportunity, this fiction has become a reality. As NASA prepares additional rovers to explore the Red Planet, the agency is looking for ways to make exploration more efficient. One solution is to use a small, lightweight, co-axial rotor helicopter to scout geographical conditions on the Martian surface. This type of flight is unprecedented, as no vehicle has flown in the Martian atmosphere. With that said, extensive experimentation is needed to develop such a vehicle. Initial testing has been completed on what has been dubbed the Mars Scout Helicopter (MSH), and the next phase of testing will include wind tunnel testing of the rotor in forward flight in a reduced pressure environment, simulating the atmosphere of Mars. To perform this test, a unique test stand has been designed to suspend the testing equipment inside the Martian wind tunnel. The stand is currently scheduled to be used for two forward flight tests, but may be further utilized as development of the MSH continues.

Diana S. Ibarra

The University of Texas at El Paso

Universities Space Research Association (USRA)

Undergraduate Intern

Mentors: Warmbrodt, William
McCoy, Miranda
Acree, Wally
Code: AV
Aeromechanics Branch

Design and Fabrication of Prototype Tiltrotor Hub via Fused Deposition Modeling Technology

The Tiltrotor Test Rig (TTR) provides a state-of-the-art system that evaluates the high speed performance of large proprotors on aircraft such as the AW609 in a wind tunnel. The TTR provides a platform for advanced research on tiltrotor technologies for military and civilian vertical takeoff and landing (VTOL) aircraft. The preliminary tunnel entry TTR hub is designed to accommodate various electronic components and sensors required for the testing and data acquisition process. However, a cowling obstructs visibility to the hub; which controls the pitch of the rotor blades. The objective of this project is to create a scaled prototype that will adequately imitate the basic mechanical interactions that take place in any general TTR hub in order to explain the functionality of the subsystem. The design, along with preliminary measurements, assemblies, and simulation of accurate kinematic movements was done using *SolidWorks*. The model's main components were produced by using the additive manufacturing technique of fused deposition modeling (FDM). To ensure pleasing aesthetics, structural quality, durability, and high mechanical properties the printing material chosen was ABS plastic. Due to its simplified geometry, the resulting model hub successfully mimics the appearance and functionality of an actual AW609 hub.

Gregory Walsh

The Pennsylvania State University

Volunteer Internship Program (VIP)

M.S. Candidate

Mentor: Dr. William Warmbrodt
Code: ARC-AV
Rotorcraft Aeromechanics

An Investigation of Coaxial Rotor Noise in High-Speed Flight

A new helicopter design that has been proposed, known as the lift-offset coaxial helicopter, enables higher speeds and a higher performance level over a traditional, single main rotor machine. Coaxial helicopters possess the potential to be used in wide spread military, commercial and industrial applications. This study aims to characterize and understand the noise that propagates from a coaxial helicopter rotor in high speed forward flight and, ultimately, discover ways to reduce the overall noise. A Rotorcraft Comprehensive Analysis System (RCAS) model of a lift-offset coaxial Sikorsky XH-59 helicopter will be used to generate blade loads and a FORTRAN based computer program, PSU-WOPWOP, will use the RCAS rotor loading and the XH-59 rotor geometry to make all noise computations. A forward flight speed of 250kts will be fixed for all cases, while the rotor RPM and differential lateral pitch will be used as variables to study the noise. Additional blade designs, blade phase positions and the number of blades on each rotor will also be explored as potential noise reduction features.

Hector David Ortiz Melendez
Polytechnic University Of Puerto Rico

Universities Space Research Association (USRA)

Undergraduate Intern

Mentors: Geoff Ament
William Warmbrodt
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Aeromechanics Branch

Rotorcraft Aeromechanics Mechanical Engineering: From Quadcopters to Mars

This spring, at the Rotorcraft Aeromechanics Branch, I contributed to the ongoing development of the Mars Scout Helicopter by performing an experimental water tunnel test. I designed two fully functional scaled-down 3D models using SolidWorks, based on the future Martian UAV, and built it at the SpaceShop using additive manufacturing. The Fluid Mechanics Laboratory testing will study how the flow interacts with the helicopter, including the box containing the instrument, and its environment. Also, I lead the reconfiguration of the Laser Lab in N-221 to host the Mars Test Stand. This stand is used for testing rotors in hover to understand how we will fly on Mars. Furthermore, I worked on the hardware analysis of a quadcopter creating a 3D model in Creo and used Finite Element Analysis determining the operational factors of safety to provide technical documentation for the AeroLab in N-243R. Another interesting project I worked on relates to the RASCAL (a full-authority, digital fly-by-wire JUH-60A Black Hawk). Its GPS hardware needs to be updated due to end of support from its manufacturer. This transition is going to be made with software add-ons. Specifically, writing a code that will hopefully pair, once again, the GPS with the aircraft to obtain the same results from the current outdated configuration.

Hector David Ortiz Melendez
Polytechnic University Of Puerto Rico

Universities Space Research Association (USRA)

Undergraduate Intern

Mentor: William Warmbrodt
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Code: AV
Aeromechanics Office

Water Tunnel Flow Visualization Experimental Study of a 15% Scale Mars Scout Helicopter

Becoming a multi-planetary species comes with a lot of challenges. Over the past few decades, much research has gone into designing equipment required to explore the Martian environment. After much success in deploying the Curiosity and Opportunity rovers on Mars, NASA aims to introduce another Martian vehicle, the Mars Scout Helicopter. Naturally, this vehicle could triple the distance the rovers currently cover in a Sol, and deliver a new level of visual information for choosing which sites to explore. As part of the research effort to accomplish this, I will test a scaled down model of the Mars Scout Helicopter in a water tunnel. In preparation for this, I designed two scaled-down SolidWorks models. These are to be 3D printed, assembled, and ultimately tested in the Fluid Mechanics Water Tunnel using a technique called flow visualization, utilizing the dye-injection method. To help study how the flow interacts with the helicopter. The smaller of the two 3D printed models is going to be tested with the rotors running while the larger of the two models will be used for static testing; obstacles will be put in the helicopters flight path to simulate how the rotorcraft will be affected by its surroundings.

Shrikant Pandya

University of Illinois at Chicago

MUREP Internship

PhD Candidate

Mentor: George Gorospe
Code: TI
Branch Title: Intelligent systems

Target Motion Control System V2.0

The latest innovation in high speed optical sensors, the Compound Eye sensor, is a system Inspired by the optical construct of a *Musca Domestica* or common house fly. The Compound Eye sensor is composed of 7 photodiodes that measure light intensity and contrast on a 2D Gaussian falloff curve at a rate of more than 30,000 times per second. This is expected to allows extremely precise and high speed tracking of movement and position. The utility of the sensor is enhanced by its small form factor, low weight, miniscule power consumption, and low cost when compared to traditional high speed optical sensors. In order to validate the sensor's capabilities, one must test the sensor with a device that can reach such speeds. The Target Motion Control System V 2.0 is low cost, robust and expandable linear rail system with the ability to move a 1 Kg load at 1 M/s over a range of 750 mm with the target itself reaching temporary accelerations of over 2 G. The system will be used to simulate the wing flex experienced by an aircraft during turbulence at 1:1 scale. Due to the necessity of rapid construction and with the idea of "open source" in mind, a majority of small components are designed to be 3D printed and easily modifiable as necessary for any environment. The target Motion Control System V2.0 will allow for further exploration into the capabilities of the sensor system, and open the door for new application domains for the Compound Eye.

Victor Hernández

Tecnológico de Estudios Superiores de Ecatepec (TESE)

NASA I²

Undergraduate Intern

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Intelligent Systems

Analysis and Visualization of Data for the Compound Eye Sensor

The ability to track motion at extremely small increments with current solutions is inefficient therefore a bioinspired optical sensor called the Compound Eye sensor was developed based on the physiological aspects of the common house fly. The Compound Eye Sensor was then refined for aerospace applications such as the measurement of wing deformation for next generation energy efficient aircraft configurations. The sensor is expected to be capable of higher performance at lower cost than prevailing imaging-based motion tracking systems.

Due to the multivariable quality of the system, data analysis can be a profoundly challenging task without graphical visualization of the data in an easily comprehensible format. The purpose of this project was to develop a method to more conveniently visualize and quantify data generated by the Compound Eye sensor, since previous implementations required a higher degree of memorization and familiarity needed for operation and navigation, operating a command line interface presented a disadvantage to researchers when the need to access and analyze data quickly is paramount. As a result, the creation of a tool to aid researchers access the data simplifies the interaction with it by representing commands as visual elements resulting in less time consumption and higher productivity.

Nathalie Nowicki

KTH Royal Institute of Technology

NASA International Internship Program

Graduate Intern

Mentor: Carl Russell
William Warmbrodt,
Code: AV
Aeromechanics Branch

Deflection Measurement and Modelling of Multicopter Rotor Blades

Package deliveries, surveillance and entertainment are all areas where unmanned aerial systems, (UAS), have a growing market. Multicopters, being one of the most common types of UAS, can both be bought and built rather easily due to the fairly simple design and low cost. However, lack of regulation means that neither safety nor proper documentation of new techniques can be guaranteed. Until today, multicopter research has mainly been done within system control and navigation, while body structure and aerodynamic characteristics on the other hand have been verified by trial and error. The absence of research into structural properties of the rotor blades motivates the purpose of this project that is to evaluate properties and deformations of commercial multicopter rotor blades in hover. These results are then to be used in a coupled FE and CFD analysis using X3D, a newly developed software by the Army, to get a more comprehensive understanding of the behavior of said blades. By doing so, standards for blade properties can be defined and regulated, thus increasing the safety of commercially available UAS. Likewise, establishing these properties lead to the development of better blades and consequently better UAS that could potentially carry more payload and increase their operational envelope.

Skylar Jordan Laham

Arizona State University

Research Associate

Undergraduate

Mentor: Brad Bebout
Code: SSX
Branch: Exobiology

Ecologically Engineered Life Support Systems and Constructed Microbial Mat Ecology

Water reclamation techniques are essential for astronaut health, hygiene, and safety. The physical-chemical wastewater treatment systems aboard the International Space Station are unsustainable, requiring restocking and implementation of hazardous chemicals to function; sustainable reclamation techniques must be developed.

Microbial mats are some of Earth's earliest known living ecosystems; contributing to Earth's thick oxygen-rich atmosphere. Mat microorganisms survive conditions of desiccation, extreme temperature fluctuations, high elevation, high radiation, hypersalinity, and simulated space flight; and seem ideal for surviving the austere conditions as part of robust astronautic bioregenerative life support systems.

Constructed microbial mats consist of artificial substrates, such as: hydrophilic open cellular foam inoculated with microorganisms from natural microbial environments, and/or isolated strains of cyanobacteria and beneficial bacteria. Throughout substrates, microorganisms distribute themselves via migration, or can be distributed artificially; recreating three dimensional laminated ecosystems found in nature, with each lamination performing distinct biogeochemical transformations according to microbial community composition and redox conditions. Constructed microbial mats reclaim wastewater, and produce and/or consume compounds and gases vital for astronautic exploration, therefore; astrobiology-based investigations of microbial mat ecology, evolution, and community composition seems highly appropriate to support extended human exploration, and in situ resource utilization technologies.

Linnea Persson

KTH Royal Institute of Technology

NASA International Internship Program

Graduate Intern

Mentor: **Ben Lawrence**
Colin Theodore
Code: **AV**
Branch: **Rotorcraft**

Flight Dynamics and Control Analysis of the Elytron 2S Experimental Tiltwing Aircraft

Elytron 2S is an experimental tiltwing aircraft, consisting of a joined-wing design with a small central wing for the proprotor. Elytron introduces an alternative approach to hover control, substituting the typical rotor hub and swash plate for linear actuators controlling pitch, yaw and roll. Split louvers placed in the wake of the proprotors are used to induce yaw and roll moments. For the pitch attitude, control is done using a tail-mounted air-blowing system. When in cruise mode, the aircraft is controlled using conventional airplane control surfaces. In this project, the stability properties and control performance of the Elytron aircraft are analyzed using NDARC, a rotorcraft conceptual design tool, and SIMPLI-FLYD, an integrated collection of software tools that enables a flight dynamics and control assessment. The control authority given when using the blowing-based control system and the louvers in hover flight is investigated, for comparison with traditional hover control. Furthermore, alternative control possibilities such as using differential collective pitch on the proprotors, or adding stability augmentation through feedback control, are investigated. All of this is done with the objective of obtaining a more complete understanding into the maneuverability and possible performance of the novel design concept that the Elytron 2S presents.

Christian Amalu

California State University, East Bay

Universities Space Research Association

Undergraduate Intern

Mentor: Richard Mogford, Ph.D.
Code: TH
Human Systems Integration Division

Development of Flight Awareness Collaboration Tool for analysis and management of inclement winter weather effects on airline operations centers.

Among the challenges that face the various operations at a given airport are the effects of winter weather. De-icing procedures, wind and visibility issues, and runway and taxiway snow cover are among the different situations that occur during winter weather. These factors can lead to substantial delays and halting of flights in progress leading to inefficient use of resources, customer dissatisfaction, and loss of revenue for the airlines. At the current moment, communications between the airline operations centers (AOC), airport authority, air-traffic control (ATC), and the flight deck are inefficient and opportunities for collaboration and data sharing are limited.

In response, the AOC Automation and Autonomy Environment Lab (A^3E) in the Human Systems Integration Division is developing a Flight Awareness Collaboration Tool (or FACT), with which the airlines, airport authority, and ATC can better manage the effects of inclement winter weather on airport operations. By integrating and centralizing many of the current resources and tools used by airline dispatchers and adding new collaboration elements to promote data sharing and situational awareness, FACT will be able to ease dispatcher workload, foster better communication, and increase overall efficiency in airline operations.